THE ANTENNA LABORATORY

RESEARCH ACTIVITIES in ---

Automatic Controls — *Antennas* — *Echo Area Studies*
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Terrain Investigations — *Radomes* — *Systems Analysis*
Wave Propagation — *Submillimeter Applications*

ANNUAL SUMMARY REPORT
1 March 1962 to 31 August 1963

Receiver Techniques and Detectors
for Use at Millimeter and
Submillimeter Wave Lengths

Grant Number NsG-74-60

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THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION
Columbus, Ohio

REPORT

by

THE OHIO STATE ~~UNIVERSITY~~ RESEARCH FOUNDATION
COLUMBUS 12, OHIO

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Investigation of — Receiver Techniques and Detectors for Use at Millimeter and Submillimeter Wave Lengths

Subject of Report — Annual Summary Report,
1 March 1962 to 31 August 1963

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ANNUAL SUMMARY REPORT

I. INTRODUCTION

The purpose of the present research program is to investigate various detection and receiver techniques, both conventional and non-conventional, in the millimeter and submillimeter wavelength regions. This report summarizes the research results in the grant period from March 1, 1962, to August 31, 1963, and outlines the research activities to be carried out in the period from September 1, 1963 to August 31, 1964.

II. RESEARCH RESULTS FROM MARCH 1, 1963 TO AUGUST 31, 1963

Most of our effort during this period has been on the development of a submillimeter radiometer. Additional work that has been carried out in this period includes the investigation of a carbon bolometer as a detector, and the measurement of the submillimeter properties of maser crystals.

A. The Submillimeter Radiometer

The interferometric-modulator radiometer which was described in Reports 1093-9[1] and 1093-14[2] has been completed except for the telescope (antenna) section in the front end. A theoretical investigation has been made to improve the frequency characteristics of the radiometer as presented in Report 1093-15.[3] The radiometer is shown in Fig. 1 and is now undergoing initial tests and minor experimental modifications. The tests completed thus far indicate satisfactory operation as predicted in Report 1093-9. The modifications are necessary to achieve the improvements outlined in Report 1093-15.

B. The Carbon Bolometer

There are two basic reasons for investigating the carbon bolometer as a submillimeter detector. One is to obtain a more sensitive detector in this wavelength region. The second is to determine the relative merits of using a mirror-type optical system, as contrasted with the use of a light pipe, for bringing the submillimeter radiation into the cryogenic container where the low-temperature detector must be located. A low-temperature (1.6°K to 2°K) carbon bolometer has been constructed and briefly tested. The detailed experimental testing was delayed because

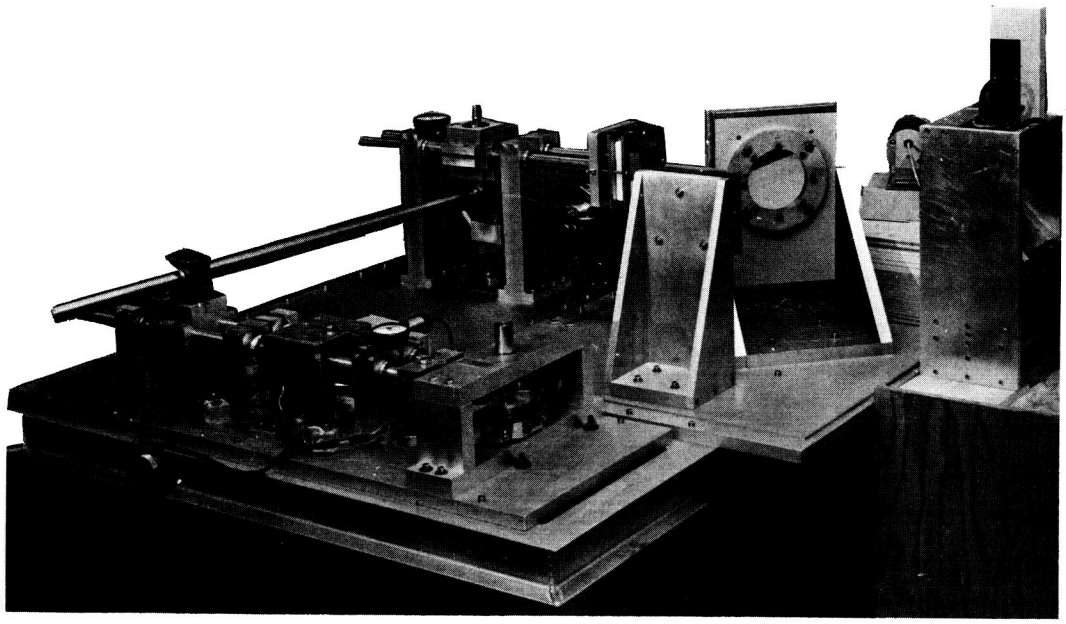
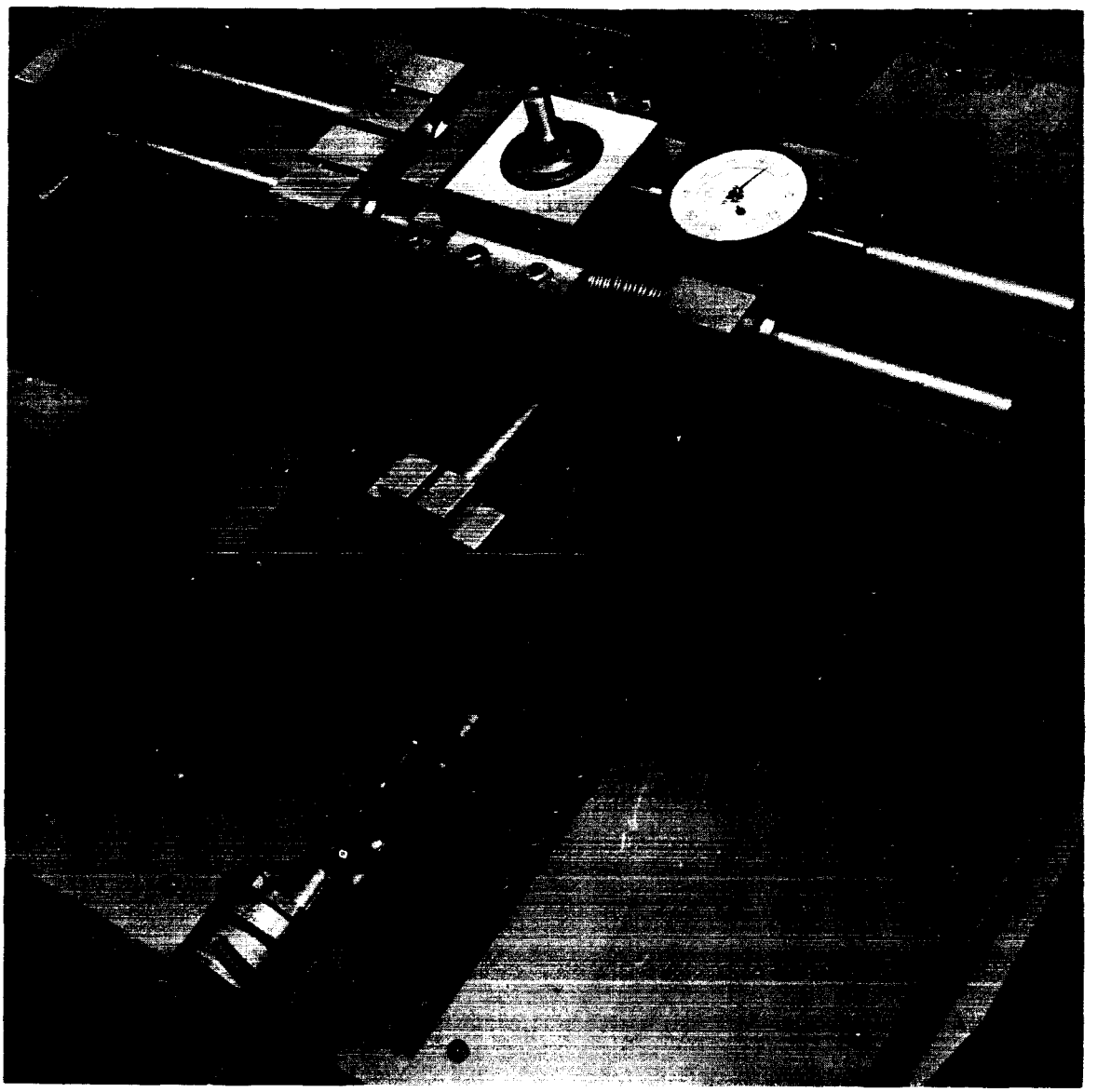


Fig. 1. The interferometric radiometer receiver.

(a) An over-all view of the receiver portion of the radiometer. In the foreground is the cam, driven by the variable speed drive which can just be seen under the table. The reciprocating can follower is to the left and carries the reference chopper reticule and, farther to the left, the ratio-arm bearing. The chopper photocell is in the foreground and the exciter lamp housing can be seen just behind the dial indicator gage which reads the cam follower position. The dial on the side of the table is the cam speed control. The ratio arm connects the cam follower assembly to the movable mirror assembly to the rear. The pivot-point positioner can be seen between the two pairs of upright supports and the pivot-point-positioner drive just to the left of the supports. To the right of the movable mirror is the wire mesh beam splitter and in front of it the fixed mirror. The detector assembly is at the far right. In the background between the detector assembly and the beam splitter can be seen the black body source and mirror used for testing the receiver.



(b) A closeup of the movable mirror, its support, and the pivot-point assembly. The dial indicator reads the position of the movable mirror which is moved back and forth by the ratio arm. The position of the ratio arm pivot-point determines the length of the movable mirror stroke. This position is adjustable by means of the lathe compound rest upon which the pivot bearing is mounted. The handle of the compound rest is turned slowly by the drive unit in the foreground, causing the instrument to scan the wavelength region of interest.

it was found necessary to completely shield the electronic instrumentation in order to prevent the bolometer system from responding to the signal from a nearby VHF-TV transmitter. It was also found necessary to improve the vacuum system. These modifications are nearly complete and experimental data are expected within the next few months. When the carbon bolometer proves to be substantially more sensitive than the Golay cell detector, it will be used in place of the Golay cell as the radiation detector in the submillimeter radiometer.

C. The Submillimeter Maser Studies

After repeated attempts to measure the absorption spectra of the Stark-effect splitting of energy levels in solids, we are convinced that a more sensitive detector than the Golay cell is required for this measurement. The experimental results have also been delayed because of damage to the vacuum seal on the liquid helium dewar. Therefore, this phase of the work has been temporarily de-emphasized until a low temperature (approximately 10°K) can be achieved in the sample space, and a more sensitive detector such as the carbon bolometer or a commercial instrument can be obtained.

D. Miscellaneous Programs

1. A further modification of the correlation radiometer analysis has been made. This brief analysis is supplementary to Report 1093-6[4] and will be distributed as Report 1093-16.[5] The summarized version has been submitted to a professional journal for publication.

2. The report on the survey of literature on laser materials is in process. This report,[6] containing more than 1,000 references, will be distributed this fall.

3. The results of the investigation of the cross-relaxation mechanism in maser materials are currently being compiled into a master's thesis and a report.

III. SUMMARY OF RESEARCH RESULTS FROM MARCH 1, 1962 TO AUGUST 31, 1963

This section is essentially a summary of the research results previously reported in Reports 1093-10 and 1093-14, and Section II of this report.

sensitive radiation detector and problems with our cryogenic systems, we propose that the submillimeter laser material studies be temporarily de-emphasized until a more sensitive detector can be obtained and a low temperature sample space can be constructed. A more sensitive detector is so urgently needed for all purposes, including the radiometer study, that we propose to purchase a commercial detector. In addition, the investigation and development of the carbon bolometer will be continued.

A. Submillimeter Radiometer Studies

1. We propose that detailed measurements on the minimum detectable temperature, bandwidth characteristics, noise, and minimum detectable sensitivity be made immediately on the radiometer to verify more completely the theory developed in Reports 1093-9 and 1093-15. The instrument will then be used this winter, when the humidity is the lowest, with a small solar telescope, or heliostat, on The Ohio State University campus in an attempt to observe solar and lunar radiation. Whether this observation will be made again at a high altitude location in the spring depends upon the results obtained at Columbus.

2. Simultaneously we propose that a Fabry-Perot Interferometer or a grating monochromator be constructed and used in conjunction with the interferometric modulator to convert it into a general narrow-band receiver. This receiver with the sensitive detector can then be used in the future to measure atmospheric absorption of submillimeter radiation, the properties of submillimeter laser materials, and to investigate other submillimeter problems such as mixing and transmission lines.

B. Submillimeter Generation Through Laser Techniques

1. We propose that the work on achieving a low temperature sample space be continued. This will allow a renewed attempt to measure the absorption spectrum of the rare-earth ions in crystals when the more sensitive detector is available.

2. We propose that the generation of submillimeter radiation by the mixing of two laser beams be investigated, first theoretically and then experimentally. This investigation is particularly interesting because (a) we already have very powerful Q-switched lasers, (b) we are already investigating these problems at the optical frequency range, and (c) we will have a very sensitive narrow-band submillimeter receiver available.

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